SCIENCE AND TECHNOLOGY BENEFIT ANALYSIS

Idaho Operations Office – Idaho National Engineering and Environmental Laboratory
Bechtel BWXT Idaho LLC

In Cell Examination System

Six TRIGA fuel rods from the Heidelberg, Germany Research Reactor were assayed using the In-Cell Examination System as a part of the test identified in Safeguards and Security Corrective Action Plan, Issue Number ID-2000-INEEL-MCA-02 associated with receipt of foreign research reactor fuels. The system was deployed in the Irradiated Fuel Storage Facility, Fuel Handling Cave, and utilized to perform gross gamma ray measurement as well as gamma ray spectroscopy to verify the burn-up to be consistent with that reported by the shipper. The system is crane-portable, and did not require permanent modifications to the facility for installation.

Benefit: The installation and testing of the In-Cell Examination System completes a part of the corrective action plan to deploy technology that can corroborate fuel properties upon receipt. The results of the gamma measurements of the Heidelberg fuel will be issued as a letter report. The gross gamma measurement shows good agreement with ORIGEN-predicted values. The gamma spectrometry was ineffective because the fuel was incorrectly oriented with respect to the spectrum detector. The test did confirm the function and sensitivity of the spectrum detector. At this time, no assay of the Hannover fuel is planned.

Qualitative Benefit Analysis		
Programmatic Risk	●	Confirmation of the fuel burn-up and identity is necessary to ensure that fuels have not been diverted, as well as ensuring that the fuel characteristics are consistent with the approved facility safety analysis.
Technical Adequacy	●	Gamma spectrometry has been used to verify burn-up of spent nuclear fuels for as much as ten years. This system uses a detector that has comparable resolution to those used historically.
Safety	●	A compact system such as this reduces the potential exposure that would be incurred during installation of another more complex technology that required permanent modifications.
Schedule Impact	○	This system was designed and constructed in a timely manner such that, when installed, it met the schedule for confirmation technology availability.

●	◒	○	◓	◉
Major improvement	Some improvement	No change	Somewhat worse	Major Decline

Quantitative Benefit Analysis	
Cost Impact Analysis	This is an enabling technology for this facility. Alternate means of confirmation would require moving the fuels in question to another facility, which would be a minimum of $500,000. A cost estimate of $1,020K is provided for movement and destructive analysis of spent fuel at an ANL-W facility.

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Addendum to In Cell Examination System

Need for deployment

This technology deployment was part of the corrective action to an I&E audit finding on the INEEL Safeguards and Security program, having to do with the receipt of spent nuclear fuel at the INEEL. This deployment addresses INEEL's Science and Technology need ID – 1.1.09.

ESTIMATE BASIS FOR: **In Cell Examination System**

Worksheet 2: Itemized Project Funding Requirements*
(i.e., One Time Implementation Costs)

Category	Cost $
INITIAL CAPITAL INVESTMENT	
1. Design	$ 120,000
2. Purchase	$ 35,000
3. Installation	$ 74,000
4. Other Capital Investment (explain)	$ 49,500
Subtotal: Capital Investment= (C)	$ 278,500
INSTALLATION OPERATING EXPENSES	
1. Planning/Procedure Development	$ 5,000
2. Training	$ -
3. Miscellaneous Supplies	$ 1,500
4. Startup/testing	$ 100,900
5. Readiness Reviews/Management Assessment/Administrative Costs	$ -
6. Other Installation Operating Expenses (explain)	$ -
Subtotal: Installation Operating Expense = (E)	$ 107,400
7. All company adders (G & A/PHMC Fee, MPR, GFS, Overhead, taxes, etc.)(if not contained in above items)	$ -
Total Project Funding Requirements=(C + E)	$ 385,900

Useful Project Life = (L) 10 Years Time to Implem 36 Months

Estimated Project Termination/Disassembly Cost (if applicable) = (D) $ -

(Only for Projects where L<5 years; D=0 if L>5 years)

TOTAL LIFE-CYCLE COST SAVINGS CALCULATION FOR IPABS-IS

(Before - After) x (Useful Life) - (Total Project Funding Requirements + Termination)

Total Life Cycle Cost Savings Estimate = (B - A) x L - (C+E+D)

RETURN ON INVESTMENT CALCULATION

Return on Investment (ROI) % =

$$\frac{\textit{(Before - After) - [(Total Project Funding Requirements + Termination)/Useful Life]}}{\textit{[Total Project Funding Requirements + Project Termination]}} \times 100$$

$$ROI = \frac{(B-A)-[(C+E+D)/L}{(C+E+D)} \times 100 \quad -10 \ \%$$

O&M Annual Recurring Costs:			Project Funding Requirements:			
Annual Costs, Before=	$ -	(B)	Capital Investment=	$	278,500	(C)
Annual Costs, After=	$ -	(A)	Installation Op. Exp=	$	107,400	(E)
Net Annual Savings=	$ -	(B-A)	Total Project Funds=	$	385,900	(C+E)

Note: Before (B) and After (A) are Operating & Maintenance Annual Recurring Costs from Worksheet 1.

* See attached Supporting Data and Calculations.

ESTIMATE BASIS FOR: **In Cell Examination System**

GENERAL

The In Cell Examination System is a crane-portable, gross gamma ray measurement and gamma-ray spectroscopy system with video camera and laser distance measurement components. The system uses a cadmium-zinc-telluride miniature semiconductor gamma ray spectrum detector approximately the size of a writing pen with preamplifier and operates at room temperature. The detector is mounted in a bismuth shield. The shield can be fitted with one of three tungsten collimator units to control saturation of the spectrum detector. The gross gamma measurements are done using ion chamber heads mounted in a partial collimator. A laser range finder is used for the purpose of measuring the distance from the source to the detector so that contact dose values can be calculated. The shielded video camera provides a view of the fuel being assayed, allowing confirmation of item serial numbers and cladding integrity. The acquired energy spectrum is used to compare a fuel object fission product isotope contents to establish the amount of burn-up of fissionable material.

INITIAL CAPITAL INVESTMENT

Initial capital investment includes design, procurement and fabrication costs and amounts to $278,500.

INSTALLATION AND START-UP

Installation and startup costs include work order planning, calibration and testing and amount to $107,400.

TRADITIONAL (BASELINE) TECHNOLOGY/METHOD

Other installations designed for gamma spectrometry have been large scale lead or concrete shielded tubes built into facilities as essentially permanent modifications. Those installations used high purity germanium detectors, which require liquid nitrogen supplied to the detector to maintain operability.

ESTIMATE BASIS FOR: **In Cell Examination System**

NEW TECHNOLOGY/METHOD

The In Cell Examination System is a crane-portable gross gamma ray and gamma-ray spectroscopy system with integrated video camera and laser distance measurement components. The system is centered around a bismuth shield unit that houses an eV Products SPEAR cadmium-zinc-telluride gamma spectrum detector. Use of bismuth provides shielding equal to lead without lead's toxic (and RCRA regulated) properties. The cadmium-zinc-telluride detector is a miniature semiconductor unit that is approximately the size of a writing pen, including its preamplifier, and operates at room temperature, eliminating any requirement for liquid nitrogen for detector cooling. The shield can be fitted with one of three INEEL-designed and fabricated tungsten collimator units (1 mm, 3 mm, and 10 mm apertures) to control saturation of the spectrum detector. The collimators are discrete units that are remotely changed by using an electro-mechanical maniuplator located in the dry handling cave. The gross gamma measurements are done using Eberline RO-7 digital ion chamber heads mounted in an INEEL-designed and fabricated partial collimator that makes an otherwise omnidirectional head sense primarily the energy entering the head from the front. An Acuity Research Accurange Class IIIa laser rangefinder is mounted in an INEEL-designed and fabricated shielded box with its axis parallel to the field of view for the purpose of measuring the distance (up to 55 feet) from the source to the detector so that contact dose values can be calculated from gross gamma ray measurements taken at a distance. The unit is shielded to minimize damage to the electronics by high radiation fields. It is also mounted behind the spectrometry detector's bismuth shield unit with the beam directed from a 90 degree mirror to eliminate direct exposure of the return sensor to direct gamma photon sources. The RJ Electronics RCS-510 shielded, radiation hardened video camera provides a view of the fuel being assayed, allowing confirmation of item serial numbers and cladding integrity. Although other cameras are present in the Fuel Handling Cave which can be used for serial number identification, their usefulness diminishes in the presence of fuels that exceed 1,000 R/hr contact fields due to noise caused by high radiation. Closeup viewing of a relatively high burnup ATR element places the camera in a 10,000 R/hr field. The method of isotope ratio comparison is used to establish the fuel burnup and fuel characteristics. The gross gamma measurment provides a determination of whether the fuel is self-protecting, and can be used to provide validation of the isotope production models used to predict source term.

ESTIMATE BASIS FOR: **In Cell Examination System**

COST SAVINGS/COST AVOIDANCE/RISK REDUCTION

The immediate alternate means for measurement would involve moving the fuel to another facility. Being able to measure these elements on-site, during repackaging for interim storage eliminates that transport cost and risk. Movement of the fuel to another facility is estimated to be a minimum of $500,000. Installation of a large scale assay system is nominally an order of magnitude higher in cost.

The costs identified for alternative measurement methods are as follows assuming that the fuel would be transported to ANL-W for examination at HFEF:

Movement of the fuel canister into HFEF-6 cask	$ 15K
Operational Readiness Review	$ 200K
Safety Analysis Review	$ 100K
Transport Planning Package	$ 10K
Loading of fuel into cask	$ 25K
Out of Commerce shipment using HFEF-6 cask	$ 15K
Procedure development	$ 50K
Training	$ 15K
Planning Controls Engineer	$10K
Project Management	$ 10K
Preventative Maintenance of Equipment	$ 5K
Miscellaneous Budget, Planning and Reporting	$ 50K
Receipt of shipment, gas analysis, profilometry, rod sectioning (3 rods), Section dissolution and radiochemistry by ANL-W	$ 520K
Total Cost	$1,020K

SCIENCE AND TECHNOLOGY BENEFIT ANALYSIS DEPLOYMENT APPROVALS

Technology Deployed: In Cell Examination System

Date Deployed: July 30, 2001

EM Program(s) Impacted: Spent Nuclear Fuel Program

Approval Signatures

8/9/01
Contractor Program Manager — Date

N/A
Contractor Program Manager — Date

8/13/01
DOE-ID Program Manager — Date

N/A
DOE-ID Program Manager — Date